TECHNICAL MEMORANDUM 1308

ENCAPSULATING PROPELLANTS BY MEANS OF ULTRASONIC WELDING

CHARLES ZGLENICKI

LOUIS SILBERMAN

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DECEMBER 1963

PICATINNY ARSENAL
DOVER, NEW JERSEY

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BY

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INTRODUCTION

An aluminum container holding M5 propellant has been causing functional problems because of inadequate sealing. Exposure of the propellant to volatiles through leaks in the seals degraded burning characteristics. Various means of sealing the containers were tried with varying degrees of success. Methods tried included various types of O-rings, silastic sealant, polyester coatings and ultrasonic welding. The ultrasonic welding approach appears to provide the most effective and durable seal. One hundred and thirty-three containers sealed by ultrasonic welding withstood 28 days temperature cycling without any detectable leakage. Thirty-five containers filled with M5 propellant were temperature-cycled and exposed to a solvent-saturated atmosphere for 11 days. Closed bomb tests of the propellant afterward indicated an effective seal was achieved.

CONCLUSIONS

Advantages:

The ultrasonic welding process is capable of economically producing hermetically sealed propellant containers.

The equipment is compact and it appears to be possible to build a unit into a Jones loader.

Meticulous attention to surface cleanliness is not requisite to achieve sound welds.

Foil thin covers which present a minimum resistance to propagation of explosive effects can be welded.

It has been demonstrated that propellant trapped in the weld zone did not ignite.

Significant cost savings can be realized in high volume production over methods using special sealants.

Disadvantages:

High initial equipment cost.

Process, at present, appears to be limited to spot welds, straight seam, or circular ring welds.

A flange of at least 0.040 inch is required for ring welds.

RECOMMENDATIONS

Ultrasonic welding should be adopted as an alternate method for sealing propellant containers where hermetic sealing is beneficial and where the design can be modified to suit the process.

ACTION TAKEN

Day and Zimmerman, Inc., at Lone Star Army Ammunition Plant, has been instructed by Ammunition Procurement and Supply Agency to investigate the equipment changes necessary to provide ultrasonic-welded seals on containers in current and forthcoming production. A program has been initiated to explore the possibility of making ring welds on oval shaped containers. A variety of other applications wherein ultrasonic ring welds may be advantageous are also being studied.

STUDY

Ultrasonic welding joins both similar and dissimilar metals through solid-state bonding by means of vibrating energy. No heat is applied to the area to be welded except that which is generated at the point of welding through dissipation of the ultrasonic vibrations. The pieces to be joined are clamped at low pressure between two welding tips, and torsional vibrating energy is transmitted through the welding tips for an interval of ½ to 3 seconds. Mechanical vibration is achieved by an alternating electrical current passing through a coil on a magnetostrictive transducer. The alternating polarity of the coil creates mechanical motion which is transmitted through a coupling member to the sonotrode.

The motion of the couplers attached tangentially to the sonotrode produces a torsional motion on the sonotrode. The frequency of vibration imparted to the couplers is in the order of 15 kilocycles per second.

A contract was placed with Aeroprojects Inc. of West Chester, Pennsylvania, to investigate the technique used by this company to make ring welds. It appeared to be a desirable way of providing a 360° weld seal in a flanged circular cross-section container. The flange is required because of the necessity for welding tip contact on both sides of the weld. The cover would thus be placed on the flange and welded. Containers with 0.040-inch-wide flanges were manufactured in 3003-0 stock 0.010 inch thick. Covers were made of 3003-H25 stock 0.003 inch thick. This particular choice of alloy was made over the 1100 alloy because the relatively soft 1100 alloy does not weld as well primarily because of sonotrode sticking. The containers were filled with dry calcium chloride to evaluate the seal after welding. One thousand containers were filled and welded in this manner. In addition, 35 containers were filled with M5 propellant and welded. Propellant was deliberately placed in the weld zone to simulate an aggravated condition. No ignition occurred in either the weld zone or container with quantities of propellant ranging from a few flakes to a generous sprinkling. These experiments were also performed with M9 propellant, which is more sensitive, with likewise no ignition occurring. The mechanical load used was 700 pounds total force hydraulically applied. Approximately 1.5 kilowatt of total electrical input to the transducers were used. The frequency used was 20 kc. The welded containers were submerged in water under 20mm mercury vacuum for five minutes with no evidence of leakage.

Figure 1 shows a model of an ultrasonic welding machine minus the electronic pack. This model is of the same size as is needed for welding the containers experimented with to date. This particular machine was built for sale to a commercial concern and was not available for these experiments. The actual machine used was a heavier-capacity machine rated at 18 kw. However, this machine was operating at only 1.5 kw. This machine is shown in Figure 2. It is reported to be capable of making 4-inch diameter ring welds. The 2 kw model is supposed to be capable of making welds up to about 3/4 inch in diameter.

The welding head proper, according to Aeroprojects, can be made explosion-proof. This would be done by isolating the high frequency current-generating equipment at some distance from the welding head. With this approach it may be possible to incorporate an ultrasonic welding head into a Jones loading machine. The welding head would replace the usual crimping station(s). A representative of Aeroprojects Inc. has examined a Jones loading machine and confirmed the opinion that this modification is feasible. Assuming that the Jones loader can be modified to accept the ultrasonic welding head, the cost of sealing containers should approximate the current cost of crimped containers minus the cost of silastic sealants currently applied. Eliminating the sealant can save as much as eight cents per container. Cost of the equipment in the 2 kw capacity is stated to be approximately $25,000. Figure 3 shows a closeup view of the filled container located in the anvil with the cover about to be positioned. The "sonotrode" is directly above. Figure 4 shows completed container assemblies.

One hundred and thirty-three ultrasonic sealed aluminum cups (0.003 cover) containing calcium chloride were JAN-cycle tested for 28 days. Weights of the cups were recorded before the JAN-cycle test. The ultrasonic seal proved to be an effective seal as noted by no increase in weight of these exposed cups and the fluffiness of the calcium chloride after the exposure. Also, 100 ultrasonic sealed cans containing calcium chloride were exposed to 100% humidity for 2½ months at ambient conditions. The ultrasonic seal was 100% effective.

Thirty-five ultrasonic sealed cups containing M5 flake propellant were cycled 12 times between -65°F and 165°F for four days and then exposed to a saturated atmosphere of acetone and cyclohexanone at ambient temperature for 11 days. After exposure, the cans were removed from the desiccator and the propellant was tested in the closed bomb. The results (Table 1) show there was a slight decrease in the relative quickness but no decrease in the relative force.

This decrease in the relative quickness could have been caused by several factors: (1) 0.003 aluminum cover being marginal as an effective vapor barrier, (2) non-uniformity of the propellant samples, (3) small quantity of test propellant necessitating the use of a small bomb (50 cc) and low loading density with its inherent lesser accuracy and (4) defective seals. However, it should be pointed out that if the ultrasonic seals were defective, the propellant would have deteriorated markedly after 11 days exposure to solvent vapors. This was not the case as evidenced by the fluffiness of the propellant when removed from the cans.

Another series of experiments was designed, using a greater quantity of ultrasonic-sealed propellant cans (150) with 0.003 and 0.006 covers and comparing them with propellant container assemblies (60) imbedded in silastic. These aluminum cans filled with M5 flake propellant are crimped over the cover; they are then placed in a well containing silastic (Dow Corning), crimp side down. The bead of silastic (Figure 5) fills the bottom as well as the side of the can.

All of these propellant-filled cans were cycled 20 times for one week at -65°F and 160°F. Some of these cans from each group (silastic and ultrasonic) were opened and the propellant removed for closed bomb ballistic tests (Table 2). The remainder of these propellant cans were then exposed at ambient conditions to a saturated atmosphere of acetone and cyclohexanone. At the end of one week some of the silastic-sealed cans were opened and the propellant tested in the closed bomb (Table 3). The M5 propellant was contaminated with solvent. Also very noticeable was the swelling of the silastic (Figure 6) around the sides of the can.

The remainder of the cans remained in the saturated atmosphere an additional eight days for a total exposure time of 15 days. These cans were then opened and the M5 propellant removed for testing in the closed bomb (100 cc). The silastic-sealed propellant cans were completely contaminated (Table 4) as evidenced by a 0% relative quickness. The propellant removed from the ultrasonic-sealed cans was fluffy and had no physical indication of being contaminated. The closed bomb ballistic results also indicate that the ultrasonic seal was effective and 0.003 covers were of sufficient thickness to protect the propellant against solvent contamination. It should be pointed out that these samples were run in the 100-cc bomb at a loading density of 0.047 to 0.048 g/cc and the precision of the instrument in conjunction with the propellant used would give results approximately an 8% spread. Therefore, taking this and the results into consideration the ultrasonic seal was 100% effective against solvent contamination.

APPENDICES

APPENDIX A

TABLES

TABLE 1

CLOSED BOMB RESULTS
OF
ULTRASONIC-SEALED PROPELLANT CANS EXPOSED 11 DAYS
TO
SATURATED ATMOSPHERES OF ACETONE AND CYCLOHEXANONE

Item and Propellant Lot No.	Relative Quickness %	Relative Force %
M5 (HES 5250.92 Lot 2)	100	100
Ultrasonic-Sealed M5 (Lot 2) Aluminum Cans	90	102

Loading Density - 0.037 g/cc

TABLE 2

CLOSED BOMB RESULTS OF CYCLED (-65°F TO 165°F) FOR ONE WEEK)
ULTRASONIC-SEALED PROPELLANT CANS
AND
SILASTIC-SEALED PROPELLANT CANS

Item and Propellant Lot No.	Relative Quickness, %	Relative Force, %
Standard M5 (HES 5250.02 Lot 2)	100	100
Ultrasonic-Sealed 0.006 Cover M5 (Lot 2) Propellant Container	105	100
* Silastic-Sealed M5 Propellant Container	112	100

Loading Density - 0.048 g/cc

* Silastic Dow-Corning 732

TABLE 3

CLOSED BOMB RESULTS
OF
SILASTIC-SEALED PROPELLANT CANS EXPOSED
FOR
ONE WEEK TO SATURATED ATMOSPHERES
OF
ACETONE AND CYCLOHEXANONE

Item and Propellant Lot No.	Relative Quickness %	Relative Force %
Standard M5 (HES 5250.92 Lot 2)	100	100
*Silastic-Sealed M5 Propellant Container	30	85

Loading Density - 0.047 g/cc

* Silastic Dow-Corning 732

TABLE 4

CLOSED BOMB RESULTS
OF
ULTRASONIC-SEALED PROPELLANT CANS
AND
SILASTIC-SEALED PROPELLANT CANS EXPOSED 15 DAYS
TO
SATURATED ATMOSPHERES
OF
ACETONE AND CYCLOHEXANONE

Item and Propellant Lot No.	Relative Quickness %	Relative Force %
Standard M5 (HES 5250.92 Lot 2)	100	100
* Silastic-Sealed M5 Propellant Container	0	47
Ultrasonic-Sealed (0.006 cover) M5 Lot 2 Propellant Container	98	99
Ultrasonic-Sealed (0.003 cover) M5 Lot 2 Propellant Container	99	100

Loading Density - 0.047 g/cc

* Silastic Dow-Corning 732

APPENDIX B

FIGURES

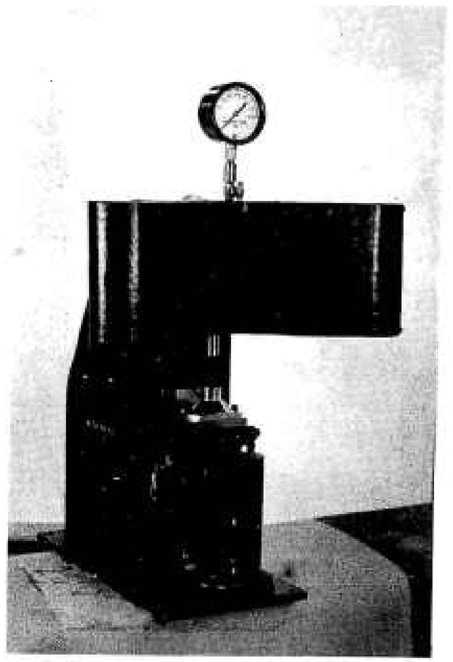

Figure 1

Commercial Version of the 2kw Ultrasonic Ring Welder

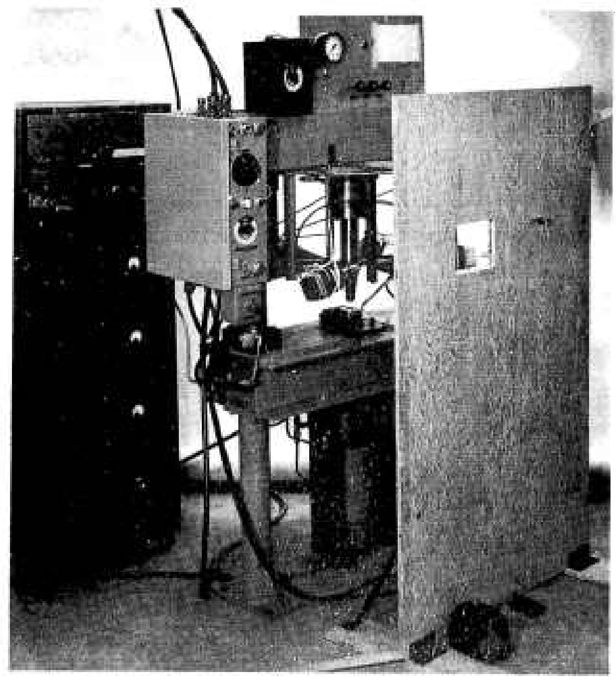

Figure 2

Laboratory-Type Ultrasonic Ring Welder
with Operator Barricade for Propellant Welding

Figure 3

Laboratory-Type Ultrasonic Ring Welder Tip
and Anvil Assembly for Detonator Welding

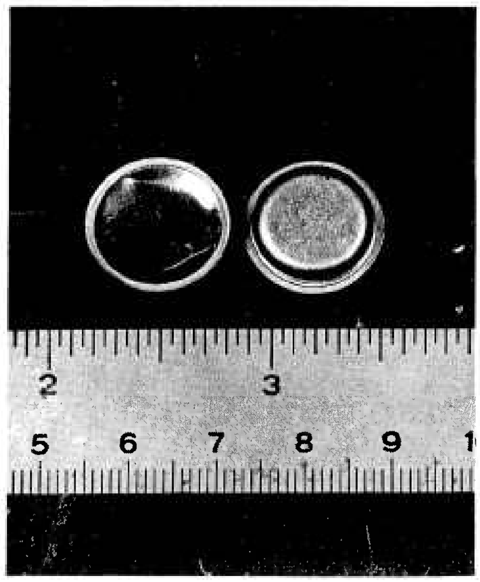

Figure 4

Ultrasonically Ring-Welded Detonator Assemblies
Containing M5 Propellant

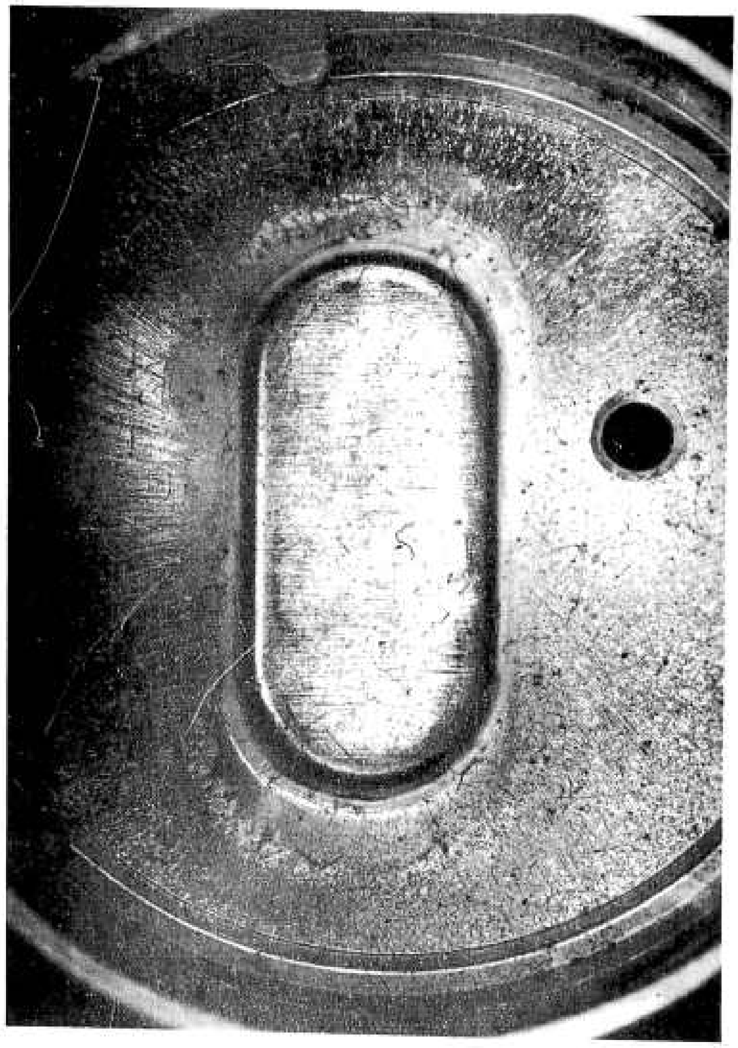

Figure 5

Propellant Container (Dwg 8847387) Showing
Bead of Silastic before Solvent Exposure
(Approximate Length of Oval Container - 1 inch)

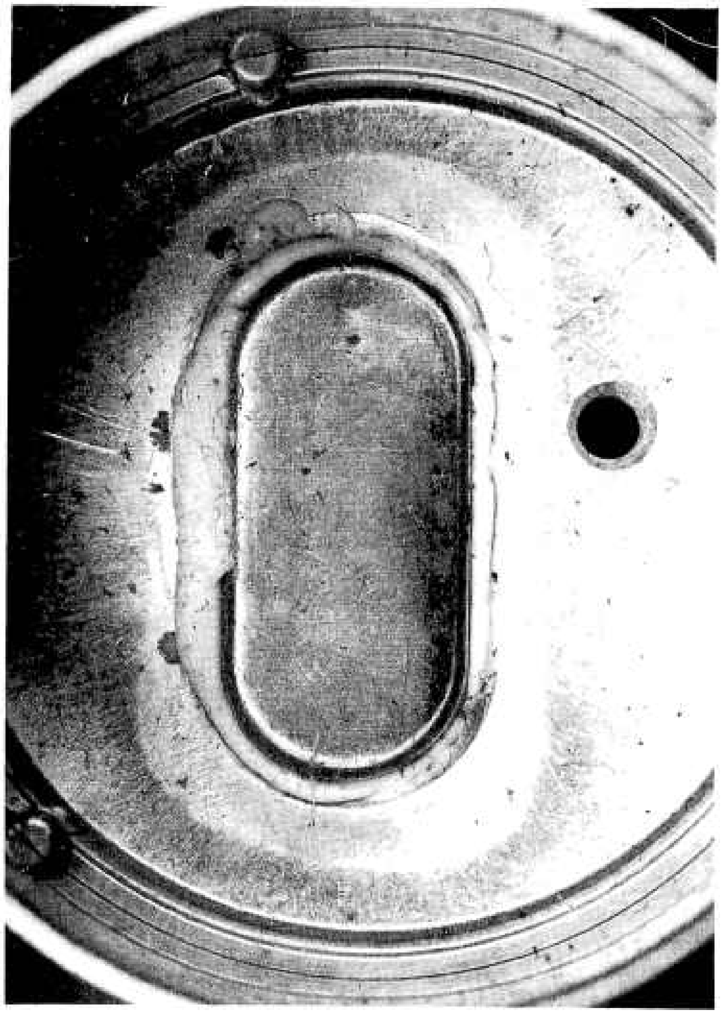

Figure 6

Propellant Container (Dwg 8847387) Showing
Swelling of Silastic after Solvent Exposure
(Approximate Length of Oval Container - 1 inch)

ABSTRACT DATA

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Technical Memorandum 1308, December 1963, 17 pp, figures, tables. Unclassified report from the Process Engineering Laboratory, Ammunition Engineering Directorate.

An aluminum container for M5 propellant caused functional problems because of inadequate sealing. A study was made of various means of sealing the container to find an effective method. Tests showed ultrasonic welding to be 100% effective. This memorandum describes the method followed.

UNCLASSIFIED

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2. Welding

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II. Ultrasonic Welding
III. Title - Encapsulating Propellants by means of Ultrasonic Welding
IV. Charles Zglenicki
V. Louis Silberman

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